Han dynasty texts on the surveying of river dykes
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Twenty-three strips of wood and bamboo acquired by the Chinese University of Hong Kong and published in 2001 provide evidence for the existence of river dikes in Hubei during the Han period, and for the government’s administration of them. Apart from the original publication, which was not extensively annotated, the texts were studied in more depth by Peng Hao in 2005. In this paper I will translate the texts and discuss the various issues they raise.

The university acquired a total of 259 slips, dating from the Warring States to the Eastern Jin. They are thus of various origins, and there is no good way to prove their authenticity or which strips belong together. Most of the slips are Western Han administrative documents dealing with such matters as fodder for livestock and the management of slaves. The unfortunate lack of provenance data makes it impossible to assume any relationship between the various types of texts, nor do the editors suggest any, so I will only discuss the strips on dikes. The 23 slips discussed in this paper are of different sizes and shapes, but all are clearly of the same origin, judging by their contents.

It is almost certain that the strips are the product of routine bureaucratic activity, probably a survey of dikes for the purpose of managing and maintaining them. The authors were also engaged in calculating the average width of these dikes, probably in order to facilitate future administration. However, the use to which that figure was to be put, is not clear. In fact, it is not clear why dikes would be measured in area at all, though it probably does provide a proxy for their size.

One aspect of these texts that is both amusing and telling is the large number of mathematical errors in the texts, which is probably evidence for the relatively weak mathematical skill of these surveyors. Although palaeographers have, of necessity, devoted considerable attention to the issue of literacy and scribal skills,

1 Chen Songchang 陳松長, Xianggang Zhongwen daxue wenwuguan cang jiantu 香港中文大學文物館藏簡牘 (Hong Kong: Hong Kong Chinese University Museum, 2001).
these are among the few texts that allow us to evaluate the level of numeracy among what were probably low-level bureaucrats.

Content

These texts are written on various sizes of bamboo and wooden strips, and can be divided into two types by content: summary strips, and measurement strips. The summary strips, which frequently begin with black dots, come in various sizes, and seem to record the total length of the dikes of the smaller political units listed on all of the measurement strips from the area. The measurement strips are wooden strips around an inch wide and under a foot long with two lines of text, the second of which begins with lü 率. These strips record the basic length and area information, compare these measurements with width-rates (廣率) and then record whether the area calculated with the width-rate is higher or lower than the original figure, along with the discrepancy. Although it seems clear that the figures on the summary strips represent the totals from the various areas described in the other strips, none of the sets are complete and so we cannot be certain.

The following explanations will be easier to understand if read alongside the texts themselves, below. The pattern for the measurement slips is: [higher level place name][lower level place name][dikes隄][altogether凡] [Length][Area][Width-rate][L x W][A-(L x W)]. The length and the area are the variables that are already known. The width-rate has already been calculated by dividing the area by the length and then rounding to the nearest fraction (either a whole number, a half, or one or two thirds). Thus the width-rate is simply a rounded average of the width, and the second part of the strip evaluates the difference between the area calculated using the width-rate and the actual area.

The pattern for the summary strips is [higher level place name][dikes隄][altogether凡] [Length][Area]. Strip 222³, the only one that discusses field areas and land reclamation, is clearly of this type.

The purpose of the measurement slips, apart from recording the length and area, is to evaluate the width-rate lü 率 in relation to the actual area, presumably to establish a

³ I will use the numbers from the original publication.
rate of measurement that will save surveyors from actually having to calculate the area manually in the future. This standard rate of measurement may represent the average width of the dike itself, or possibly the road on top. It is possible, but unlikely, that it represents a measurement of some other kind of embankment with agricultural application.

**Mathematical issues**

In the Han, 1 bu 步 = 1.38 m and 1 li 里 = 415 m. In both the Mt. Zhangjia mathematical texts and the Jiuzhang suanshu, 1 li = 300 bu, 1 qing 頃 = 100 mu 步, and 1 mu = 240 bu. So a mu is 457.056 m$^2$ and a qing is 45,705.6 m$^2$. An acre, by comparison, is 4,047 m$^2$ and a hectare is 10,000 m$^2$. The phrases 大半步 and 少半步 mean 2/3 and 1/3, respectively.

The phrase “畸（多或少）實 number 步” refers to the difference between the actual area and that measured with the width-rate. Chen Songchang and Peng Hao both read ji 異 as ji 奇; but since the former is defined as “odd pieces of land that would not fit into the square system of dividing the land” and “surplus..fractional remainders,” there seems no reason to read it as 奇, which simply means (fractional) surplus. In this case it refers to a figure that can be positive or negative, and is thus best translated as “discrepancy.”

In mathematical terminology, shi 實 usually signifies the dividend in an equation, the original number that is to be divided. This technical meaning comes from its original meaning of “full, solid.” In this case the shi functions as the dividend when it is divided by the length in order to calculate the width-ratio, a calculation that must have happened, but is not mentioned. The shi here refers to

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7 Cullen, *The Suan shu shu*, 27.
the actual area of land. The length is multiplied by the given width-rate, and the result is subtracted from the shi in order to achieve the difference (if any) between the two. Chen originally punctuated the text with a comma before the shi, implying that he read it as something like “remainder.” Thus the phrase “奇少,實十步” would mean “the surplus is negative, the remainder is 10 bu.” However, as Peng noted, this is incorrect. If we eliminate the comma then “奇少實十步” means “the discrepancy is fewer than the actual size by 10 bu,” which seems more likely. If this is correct it might also explain why the ji or shi are sometimes omitted. It can perhaps be considered a scribal error, but I believe the phrase means the same thing if either ji or shi is omitted. Therefore, unlike Chen and Peng, I have not added them in the transcription. If we read the duo or shao as a verb, i.e., “the discrepancy reduces the dividend by 10,” which means the same thing, it would be necessary to add the missing graph.

The graph 衚, read as lü 率, signifies some kind of standard rate of measurement, which is its normal meaning in early mathematical texts. The term appears in the Mt. Zhangjia mathematical texts and in the Jiuzhang suanshu 九章算術, both Han texts. Equations based on lü 率 were important in early mathematics because they dealt with calculating exchange value without fractions because coins were the lowest form of currency and could not be divided. Thus instead of treating the coin as the standard, one had to be able to measure one object using the other as the unit of value, as expressed in the common phrase “以(specific unit of measure)率之. The second juan of the Jiuzhang suanshu, which is concerned with converting between grain prices, begins with a list of grain price rates, followed by the rule of conversion between them. Liu Hui’s (263 AD) commentary reads:

“That which will be used as a rate must be equated with a unit. According to [the exchange rules] millet’s rate is 5 and hulled millet's rate is 3. This is millet 5 per unit, hulled millet 3 per unit. To exchange millet for hulled millet, first regard millet as the unit. [One] unit is to be divided by 5. That is 5 as unit. Multiply it by 3, that is [one] unit as 3. Hence the rates for [one] unit are equivalent, that is 5 to 3.”

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8 Peng Hao, “‘Hedi jian’ jiaodu,” n. 3.
9 I.e., if 5粟 = 3米, how do we calculate 1粟 in terms of 米? 1 ÷ 5 x 3 = 3/5. 1粟 = 3/5米. This translation is based on that found in Shen Kangsheng et al. The Nine Chapters on the Mathematical Art: Companion and Commentary, Oxford : Oxford University Press, 1999, 142, but I have modified the
This shows that lü rate is used to establish one type of material or measurement as the unit of calculation.

The phrase 不率 (率) appears at the end of strips whose difference from the actual size is -490, -150 and -810 bu² while it does not appear at the end of strips which differ by 50, 135, 160, 250, 700, -1,192 and 62 2/3 bu². Thus it might seem that bu lü is usually used when the discrepancy is negative, especially since strip 209, which is where the -1,192 comes from, has multiple errors. However, Peng cites a passage from the Mt. Zhangjia Zouyanshu which suggests that it simply means not equal to the rate: 行道六十日，…行5146里。率之，行日85里，畸46里不率 If someone travels 60 days, and covers 5146 li we can take 85 days as the rate, with a remainder of 46 li (5146 = (60 x 85li) + 46)¹¹ Thus it is probably simply a more verbose way of describing a discrepancy.

One of the most interesting aspects of these texts is the large number of mathematical errors. The initial calculation of the width-rate, while not always perfect, is usually pretty accurate. However the calculations represented by these strips are often incorrect. Of eleven intact strips which calculate width-ratio, seven have errors of multiplication. Most of these errors can be traced to the accidental use of the wrong figure in multiplication, which is probably due to incompetence in the use of counting rods. The counting rod system, while capable of doing complex mathematics when used by a professional, was nonetheless far more difficult than an abacus, and therefore it is quite possible that a poorly trained official, or assistant, was simply not very good at using them. But it also seems probably that none of the errors was off by such a significant degree as to make the results unusable.

Location

The texts are clearly administrative texts used for keeping track of the sizes of river dikes and, in one case, for recording the amount of arable land that can be

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¹⁰ Jiuzhang suanshu 九章算術, 24.
¹¹ Peng “‘Hedi jian’ jiaodu,” 73.
reclaimed. I assume that these dikes are long dikes along rivers, used to protect from seasonal inundations, not polders or collections of small dikes, and that the area discussed on strip 222 is land made arable by the construction of dikes. It is quite possible that the measurements discussed on each text could represent the length of all the river dikes from the specified administrative unit; I translate dike in the plural only because English does not allow the numerical ambiguity of Chinese.

It is also worth noting that these embankments may represent something completely different from a dike to protect from flood water. It does seem strange to first measure the exact area of a dike and then calculate its average width, when it would seem that one could have done that without bothering to first calculate the area. But the phrases he di 河隄 and 江隄 are not likely to refer to anything other than river dikes, and if Peng is right that the location is in Hubei than this is not surprising.

Peng begins his discussion of location by mentioning that Yicheng 宜成 is the name of a place in Shandong known from the Han shu, but argues against this being the same place because there is nowhere in Shandong with so many river dikes.12 However, Yicheng was located directly beside what was then the Ji 濟 river, and therefore was exactly the place one might expect there to be river dikes, and we know that the state of Qi did build dikes to protect itself from flooding.13 But according to the Zhongguo lishi dituji there was an Yicheng located on the Han river about 100km north of modern Jingmen city, Hubei.14

Peng argues that the Jingling 竟陵 mentioned in strip 214 refers to a county of the same name mentioned in the Han shu as being on the banks of the Han river. However, only the bottom half of the graph is visible, and Chen had originally not transcribed it. It may well be jing, but it may not. Jingling is located about 150km due west of Wuhan on the Han river.

Peng does not mention the 醴陽 located to the southeast of Changsha (in a flat

12 Peng "‘Hedi jian’ jiaodu," 74.
13 Yang Kuan 楊寬, “Zhanguo shidai shuili gongcheng de chengjiu” 戰國時代水利工程的成就 in Zhongguo kexue jishu fuming he kexue jishu renwu lunji 中國科學技術發明和科學技術人物論集 ed. Li Guangbi 李光壁 & Qian Junye 錢君暘 (Beijing: Sanlian, 1955), 103-5.
river valley well-suited to river dikes, it must be noted) according to the *Zhongguo lishi dituji*, but rather suggests a location on the Li 澧 river which flows just south of the Yangzi river in the same region.\(^\text{15}\)

Ruo Xiang 若鄉 would appear to be associated with鄀郲, located beside the Han river 10km from Yicheng. However, Peng notes that the Mt. Zhangjia *Ernian lüling* 二年律令 and the *Han shu dilizhi* both include lists of the counties included in Nan jun 南郡 and both of these include Jingling, Liyang and Yicheng. Neither includes a Ruo xian. Because the *Ernian lüling* is an early Han text, Peng concludes that the absence of Ruo xian shows that this text was produced before Ruo xiang had been upgraded to Ruo xian, and thus it must be an early Han text.\(^\text{16}\) The problem is the earliest evidence he presents for Ruo xian becoming a xian is the *Shuijing zhu*. Moreover, its seems that the three other place names were all in use into the Eastern Han. Thus I don't see any reason to date these texts specifically to the early Western Han.

Peng considers these texts evidence of the development of new agricultural land, and strip 222 is clear evidence of this. However, there were dikes in the region centuries before the Han, so it cannot be assumed that these dykes were new. We know from the *Zuo zhuan* that there were dykes in Chu much earlier. In 548 B.C. Wei Yan 蒭掩 was appointed minister of war in Chu, and immediately calculated the entire resources of the state:

Wei Yan recorded the ground and fields, measured the forests in the mountains, added up the wetlands and marshes, distinguished hills from tombs, noted barren and saline ground, calculated border wetlands, regulated embankments, put livestock to graze in marshy places, divided fertile land into grids, and adjusted the fu tax based on the income of each area 蒭掩書土田，度山林，鳩藪澤，辨京陵，表淳鹵，數疆潦，規偃豬（潴），町原防，牧隰皋，井衍沃，量入修賦.\(^\text{17}\)

This passage shows not only that there were dikes (偃豬) in place in the Spring and Autumn period, but also that the Chu government was measuring and recording...
them. Thus these texts must be understood as continuing a practice that was not at all new in the Han, but for which we have lacked direct evidence.

Although they are few, and their content is relatively simple, these texts provide a glimpse into the world of surveyors in Hubei during the Han period. They are also important sources on early numeracy and practical mathematics. And they are rare primary sources on the conversion of wetlands into farmland and of the government’s role in this process.

Text and translation

200

南鄉南坸凡十八里百七十步，積五萬五千六百五十步。

The South Village South Gou dikes are altogether 18 li 170 bu (5,570 bu/7,704.6m); their area is 55,650 bu² (106,000m²). Calculating at the rate of 10 bu wide, the total area is 55,700 bu², and the discrepancy exceeds the actual area by 50 bu².

201

南鄉宜禾隄凡十三里百卅步，積二萬五千九百八十步。

The South Village, Yihe dikes are altogether 13 li 130 bu (4,030 bu/5,574.4m); their area is 25,980 bu² (49,500m²). Calculating at the rate of 6 ⅔ bu wide, the area is 25,490 bu², and the discrepancy is lower than the actual area by a 490 bu² difference from the rate.

202

南鄉靡隄凡十里廿步，積四萬三千八百步。

The South Village, Mo dikes are altogether 10 li 20 bu (3,020 bu/4,177.6m); their area is 43,800 bu² (83,400m²). Calculating at the rate of 14.5 bu wide, the area is 43,935 bu², which exceeds the real area by 135 bu².

203

As Peng notes, 4030 bu x 6 1/3 = 25,523 bu, not 25,980. It is possible that the original calculation to determine the width-rate was done with a "correct" figure close to 25,523, and then the subtraction which determined the difference between "real" figure and width-rate was done with the current, incorrect figure (25,980). If so, the difference should be +33, not -490.

3020 x 6 1/3 = 43,790, not 43,935. Probably they miscalculated by accidentally using 3030 instead of 3020.

20

The black dots represent black dots on the strips themselves.
The Moyang Xiang river dikes are altogether 30 li 246 bu (9246 bu/12,790m); their area is 45,000 (or 40,500, etc.).

204

莫陽鄉桃丘隄凡十二里八十步，積二萬二千二百廿步。
率廣六步，積二萬二千八百步，畸多實百六十步。

The Moyang Village Taoqiu dikes are altogether 12 li 80 bu (3680 bu/5090.4m); their area is 22,920 bu² (43,600m²). Calculating at the rate 6 bu wide, the area is 22,080 bu², and the discrepancy exceeds the true size by 160 bu².

205

莫陽鄉徹丘隄凡八里百廿步。

The Moyang Village Cheqiu dikes are altogether 8 li 120 bu (2520 bu/3485.6m); their area is 7,560 bu² (14,400m²). At the rate of 3 bu wide, the area is 7,560 bu².

206

□陽鄉徹凡卅六里，積八萬二千五百五十步。

The ?yang Village dikes are altogether 46 li (13,800 bu/19,090m); their area is 82,550 bu² (157,200m²). At the rate of 6 bu wide, the area is 82,800 bu², and the discrepancy exceeds the actual area by 250 bu².

207

北陽縣河隄凡七十二里七十步，積廿萬七千卅步。

The North Village river dikes are altogether 72 li 70 bu (21,670 bu/29,977m); their area is 27,030 bu² (51,475m²).

208

北陽京（橐？）□隄凡卅二里六十步，積七萬九千八百步。

The North Village ? dikes are altogether 32 li 60 bu (9660 bu/13,362.8m); their area is 79,800 bu² (153,400m²). Calculating at the rate of 8 bu wide, the total area is 80,500 bu², which exceeds the actual area by 700 bu².

209

北陽橐中隄凡卅里百六十步，積八萬五百八十步。

The North Village Tuozhong dikes are altogether 30 li 60 bu (9060 bu/12,532.8m); their area is 80,580 bu² (153,300m²). Calculating at the rate of 8 bu wide, the total area is 80,580 bu² (153,300m²). Calculating at the rate of 8 bu wide, the total area is 80,580 bu² (153,300m²).

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21 This is an error: either the final number should be -840 or one of the other numbers is miswritten. Because the difference between correct discrepancy and the one written is exactly 1000, we can guess that the original area was probably 21,920, then the scribe wrote 2 in place of 1, in which case the discrepancy would be 160, as written.
area is $79,386 \frac{2}{3} \text{ bu}^2$, and the discrepancy is lower than the actual area by $1,192 \text{ bu}^2$.\textsuperscript{22}

\textbf{210}

若鄉河隄凡廿七里百六十步，積六萬四千五百百卅五步。
The Ruo Village river dikes are altogether 27 li 160 bu (8260 bu/11,425.8m); their area is 64,545 bu$^2$ (122,900 m$^2$).

\textbf{211}

若鄉北隄凡九里百五十二步，積萬八千二百步。
The Ruo Village ? north dikes are altogether 9 li 52 bu (2752 bu/3806.8m); their area is 18,000 bu$^2$ (34,300 m$^2$). At the rate of \(\frac{6}{3}\) bu wide, the area is 18,062 \(\frac{2}{3}\) bu$^2$, and the discrepancy exceeds the actual area by \(\frac{62}{3}\) bu$^2$.\textsuperscript{23}

\textbf{212}

若鄉兗隄凡廿二里一百五十步，積四萬八千一百步。
The ? Village Ying dikes are altogether 22 li 150 bu (6750 bu/9337m); their area is 48,100 bu$^2$ (91,600 m$^2$). At the rate of \(\frac{7}{3}\) bu wide, the area is 47,950 bu$^2$, and the discrepancy is lower than the actual area by a 150 bu$^2$ difference from the rate.\textsuperscript{24}

\textbf{213}

若鄉兗隄凡廿二里一百五十步，積四萬八千一百步。
The ? Village Yanjian dikes are altogether 15 li 30 bu (4530 bu/6266.4m); their area is 31,010 bu$^2$ (59,100 m$^2$). At the rate of \(\frac{6}{3}\) bu wide, the area is 30,200 bu$^2$, and the discrepancy is below the actual area by a 810 bu$^2$ difference from the rate.

\textbf{214}

竟陵河隄凡百二十里八百步。
The Jingling river dikes...8 li...

\textbf{215}

...里百二十步...積...百...步...步...五百五十四步。
\(\ldots\text{li} 120 \ldots\text{area}...554 \text{ bu}^2\).

\textsuperscript{22} There are two errors here. First, 9060 x 8 2/3 is 78,520, not 79,386 2/3. If we divide 79,386 2/3 by 8 2/3 we get 9160, which was probably the original length, miscopied as 9060. If this was the case there would have been no discrepancy. The final error (80,580 - 79,386 2/3 = 1193 1/3, not 1,192) is not so easy to explain.

\textsuperscript{23} There is an error here. 2752 x 6 1/3 = 17429 1/3, not 18,062 2/3. As with many of the others, this error can be explained by a single digit error. If the original figure had been 2852 and the 8 miswritten as a 7, that would explain the error, and there would be no discrepancy.

\textsuperscript{24} As Peng points out, 7 1/3 x 6750 bu = 49,500 bu rather than the stated 48,100. It is unclear how this error was made.
216
...(廿？)八萬六千四步。25
86,004 bu².

217
...萬六千六百□□步...
...五十步，多實三百步。
...(?multiple of) ten thousand, six thousand, six hundred...bu...50 bu², over the actual area by 300 bu².

218
...千九百五十步□實四千五十四步，不率。
...?950 bu². (Over/under) the actual measurement by 4,054 bu² different from the real rate.

219
...步，積...百五十六□卅八萬一千...
...bu. Area...?56 381,000...

220
...六千九百...
...6,900...

221
宜成河隄凡三百二十三里廿六步，積七十一萬九千六百一十八...（步）。
The Yicheng River dikes are altogether 323 li 26 bu (96,926 bu/134,081m); their area is 719,618 (bu²) (1,370,400m²).

222
Front
宜成隄凡三百廿三里廿六步，積七十一萬九千六百一十八...（步）。
•凡隄能治者九百廿一里二百廿步，積三百一十八萬一千八百一十二步，□
（為？）田一□（百？）（卅）
二頃五十七畝（歴）百九十二步 26 •醴陽江隄卅九里二十□步 27。
•凡隄不能治者三百廿一里二百二十七步 •大凡千二百八十三里八十九步。

25 Chen reads a nian 廿 reads while Peng does not. The published picture is illegible.
26 Chen does not have the “為” or the “百卅” both of which were added by Peng. The “為” and “百” are possible, though unclear, while there is clearly no “卅”. Peng seems to have calculated it (correctly) from the previous figure. He also argues that the following 9, clearly visible on the strip, is an error that should be a 3, for 132 bu instead of 192 bu. However, neither figure matches exactly with the preceding figure (132 qing 57 mu 192 bu) according to the rates (1 qing 塍 = 100 mu 畝 and 1 mu = 240 bu) given above, whether we agree with Peng’s addition of a ”卅”, for 132 qing, or not, in which case it is 102 qing.
27 Peng has “卅九里二百廿二步”, which he derived by subtracting the other subtotals from the grand total.
Back
実三百一十八（萬）方 28 一千八百七十二
•三百人分之，人得四步（歐）卅六步，有（又）三十分之七十二。□□ 29 醴陽
隄三十九里二百廿二步。
The Yicheng dikes are altogether 323 li 26 bu (96,926 bu/134,081m); their area is
719.61 (8 bu²) (1,370,400 m²). • Altogether the dikes that can be managed equal 921 li
240 bu (276,540 bu/382,546m). Their area is 3,181,812 bu² (6,059,500m²). This can
make 132 qing 57 mu 192 bu of fields (3,181,872 bu²). 29
The Liyang river dikes are 39 li 222 bu (11,922 bu/16,491m). Altogether the area of dikes
that cannot be managed is 321 li 227 bu (96,522 bu/134,081m). The overall length is
1,283 li 19 bu (384,919 bu/532,471m). 30

Back
The actual area is 3,181,812 bu². If 300 people divide it, each will get 44 mu, 46 bu and
72/300ths of a bu². The Liyang dike is 39 li 222 bu.

223
□□□□隄凡三百八十里，其□□□□，不能治百□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□
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Bibliography


28 The strip is broken at this point, but there must be a wan. Both editors consider ‘fang’ a scribal error, but it could be a different form of the “wan” graph.
29 Note the error of 60 bu.
30 The total length of the Yicheng dike, the “dikes that can be controlled” and the Liyang dike (323 li 26 bu + 921 li 240 bu + 39 li 222 bu = 1,284 li 188 bu (389,957 bu)) is 5038 bu higher than the stated total of 1,283 li 19 bu (384,919 bu/532,471m), which is very close. However, one would expect the “dikes that can be controlled” to be an entirely separate category, so it may be a coincidence.


